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TECHNICAL NOTE

SOME COMPUTED EFFECTS OF FRESH WATER IN THE SONAR DOME OF THE AN/SQS-26

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TECHNICAL NOTE

SOME COMPUTED EFFECTS OF FRESH WATER IN THE SONAR DOME OF THE AN/SQS-26

I. <u>INTRODUCTION</u>

This technical note presents computed results and conclusions on the effects in the vertical patterns produced by fresh water in the dome cavity of the AN/SQS-26 at a relative bearing of 80^o and at a depression angle of 30^o. Recent tests on the U.S.S. Wainwright revealed serious errors in the vertical directivity pattern for the depressed beam. It has been suggested that the errors were produced by fresh water in the dome. This note presents computed estimates of the errors produced by the fresh water.

Also, it was suggested that a temperature differential between the water in the dome and the sea water may have existed. Results of a "worst case" analysis on the combined effects of fresh water and temperature differential are presented.

II. METHOD

The analysis of the error is based on a ray theory approximation of the acoustic system. The AN/SQS-26 dome skin will be used as the boundary between the fresh and saline water. In the present analysis the effects of the dome skin will not be included. However, these effects were considered in an earlier memorandum (See TRACOR Document Number 63-248-C, "Some Computed Effects of Dome Skins and Temperature Differential on Operation of the AN/SQS-26 Sonar Equipment (U) "). The effect of the fresh water is to produce a lower propagation velocity. Since the path length through the dome cavity is different for each element, the phase relations across the wave front are distorted. In Fig. 1, the path length "a" is greater than path length "b", resulting in a phase advance of path "a" relative to path "b". Sections (See Fig. 1) were made for the twenty-four (24) staves, and the path lengths for all 192 elements were measured for a relative bearing of 80.0° and a tilt of 30.0°. A typical section is shown in Fig. 2. The data used to generate these sections were taken from BuShips Drawing Number DLG26-404-1994384 Rev C. The differential velocity at the mid-frequency produces a phase advance of 0.877009 degrees per inch of travel. These differential phases were added to the system phases, then a farfield pattern was computed.*
The system phases in Table 1 were determined for a homogeneous saline condition, and the differential phases are distortions produced by the presence of fresh water.

A water temperature in the dome cavity 10°F below the outside ambient, plus the fresh water distortion results in a 1.0962 degrees per inch of travel phase advance relative to a homogeneous saline medium.

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*The computor model of the cylindrical array is based on "Directionality Patterns for Acoustic Radiation from a Source on a Rigid Cylinder," D. T. Laird and H. Cohen, JASA, Vol. 24, January, 1952, pp 46-49.

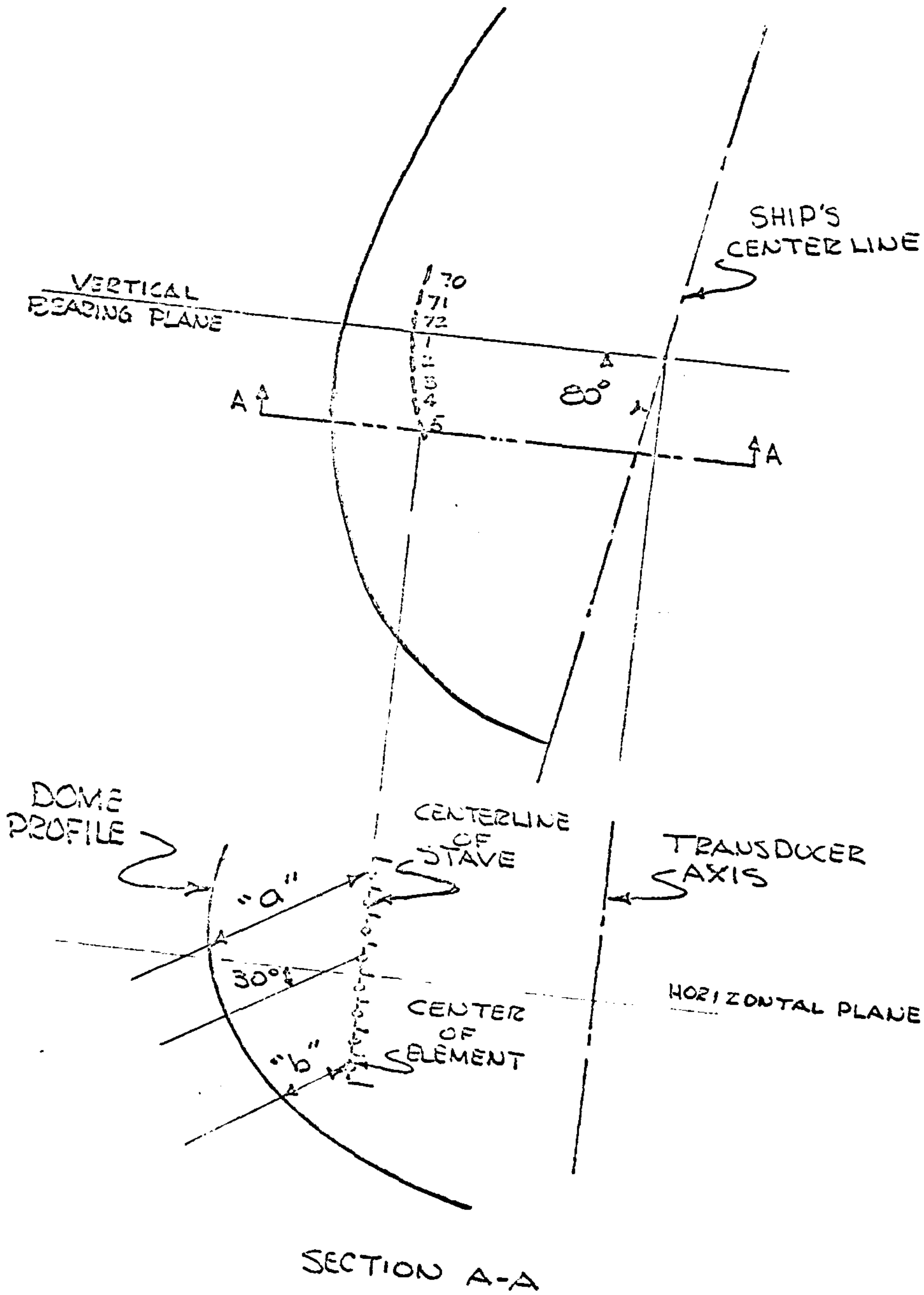


FIG 1 - DOME GEOMETRY

Stave No. B
Tilt 30°

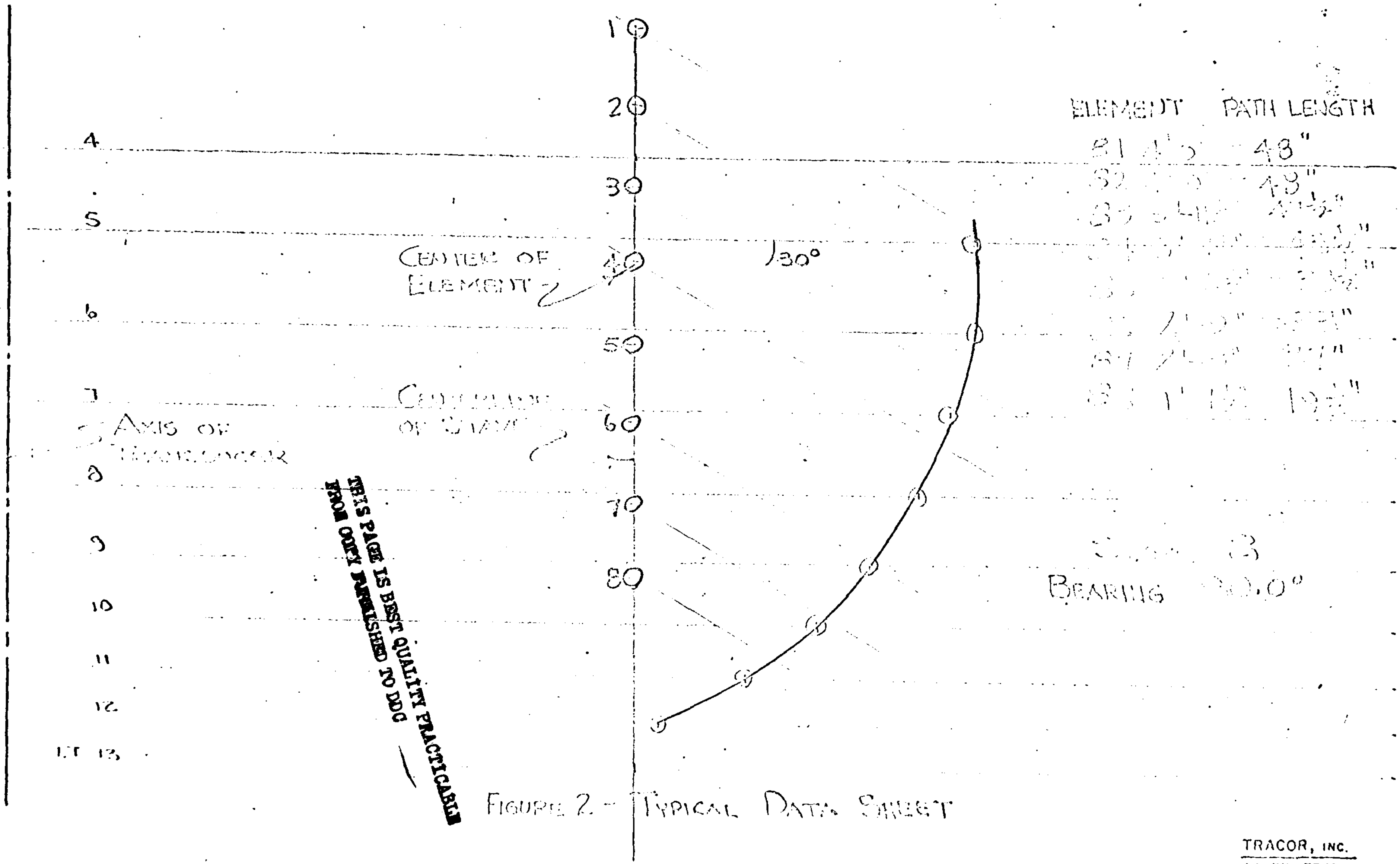


Figure 2 - Typical Data Sheet

III. RESULTS

This note contains the computed results for four sample cases at a relative bearing of 80° and a beam tilt of 30°. These results are shown in Figs. 3, 4, 5, and 6. Fig. 3 shows the composite vertical transmit pattern through the acoustic axis for the "ideal case"; i.e., where only the normal system phases shown in Table 1 were used in the computations. Fig. 4 is the computed vertical pattern produced using the phase distortions due to fresh water added to the normal system phases. In both figures the patterns are normalized to the response at 30.0° depression. A comparison of the two patterns reveals: 1) a reduction of 1.0° in depression angle, 2) a slight broadening of the vertical beamwidth of 0.5°, and 3) a decrease in the side lobe level of 1.0 dB, by the presence of fresh water in the dome cavity.

The results in Figs. 5 and 6 are for a single stave. Fig. 5 is a computed vertical pattern for the "ideal case", i. e., using the vertical phases shown in Table I, with no differential phase shifts. Fig. 6 is a "worst case", including the effect of phase shifts caused by both fresh water and temperature differential. The "worst case" here was determinded by the stave with the greatest variation in path length between the elements and the dome skin. For the 80° relative bearing, the "worst case" stave was the last active one toward the bow (at $22\frac{1}{2}^{\circ}$ relative bearing.) For this case, in addition to the fresh water distortion, an additional factor of a 10°F temperature differential was included. The direction of the temperature differential was chosen to produce an additional reduction in propagation velocity, i.e., cooler inside the dome. The combined effects of fresh water and the 10°F temperature differential results in a 5% reduction in propagation velocity inside the dome, or a differential phase shift of 1.0962 degrees per inch of path in the fresh water. Data from Figs. 5 and 6 indicate: 1) a reduction of 2.0° in depression angle, 2) a 0.25° increase in vertical beamwidth, and 3) an increase in side lobe level of 0.5 dB, as a result of the phase distortion.

No computations to include the effect of phase shifts in the dome skin were made during this brief study. However previous work[2] was done in this area for several bearings. The set of phase shifts which showed the largest variations for both a 10° temperature differential and the dome skin are reproduced here as the bottom set in Table II. The average variation in differential phase in the vertical is about 7 or 8°, which is small compared to that for fresh water shown in the top of Table II. Thus, it is concluded that the effect of the dome skin would be small compared to that for the fresh water and that their combination would not be much different than for the fresh water alone.

[2] "Some Computed Effects of Dome Skins and Temperature Differential on Operation of the AN/SQS-26 Sonar Equipment (U)", TRACOR Document Number 63-248-C, CONFIDENTIAL.

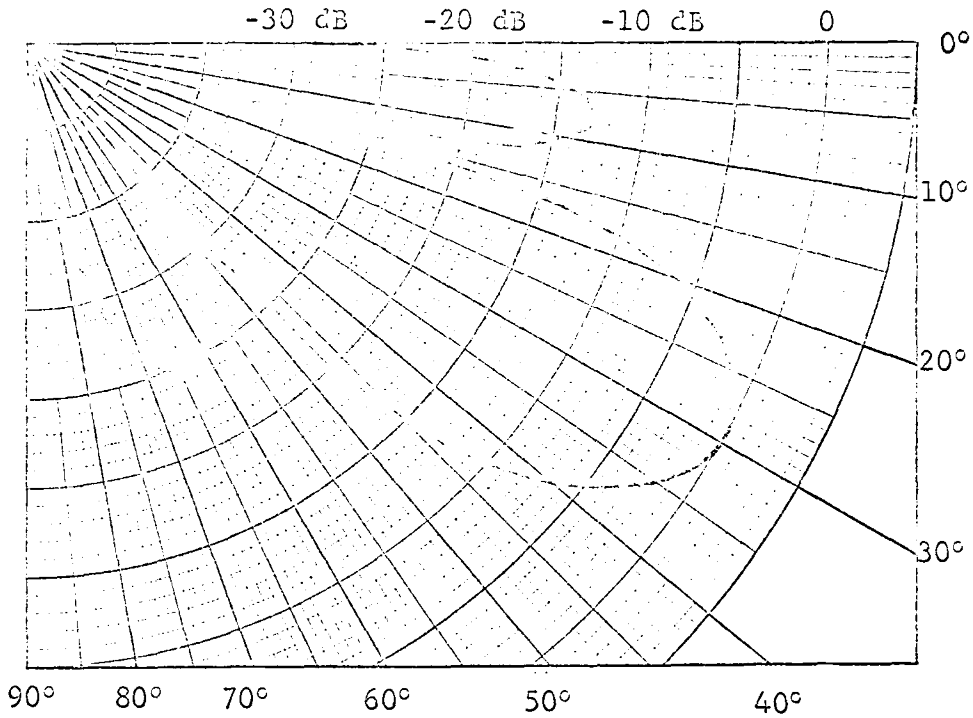


Figure 3 — Vertical Pattern at Bearing 80.0° for the 8X24 Array - Ideal Case

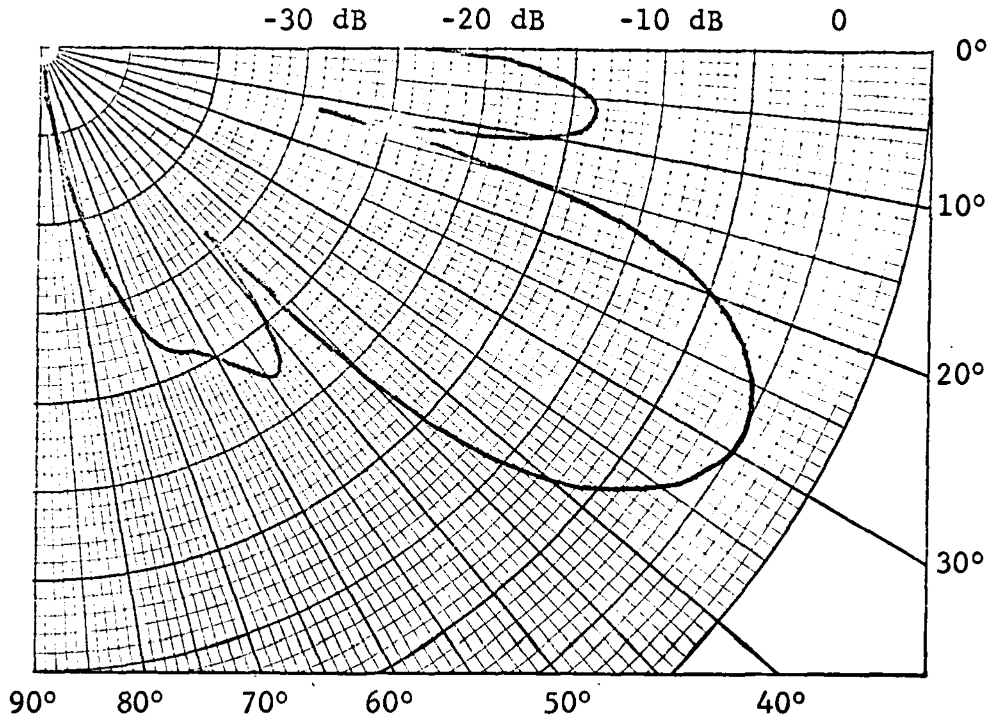


Figure 4 — Vertical Pattern at Bearing 80.0° for the 8X24 Array - Phase Distortion Due to Fresh Water Added

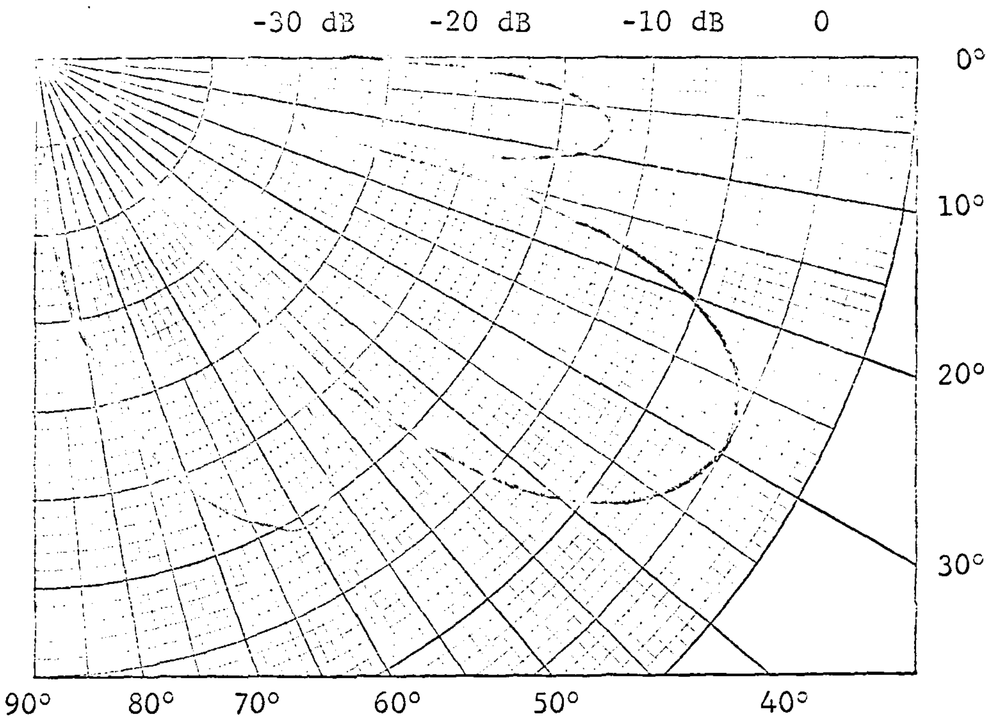


Figure 5 — Vertical Pattern at Bearing 80.0° for the 8X1 Array - Ideal Case

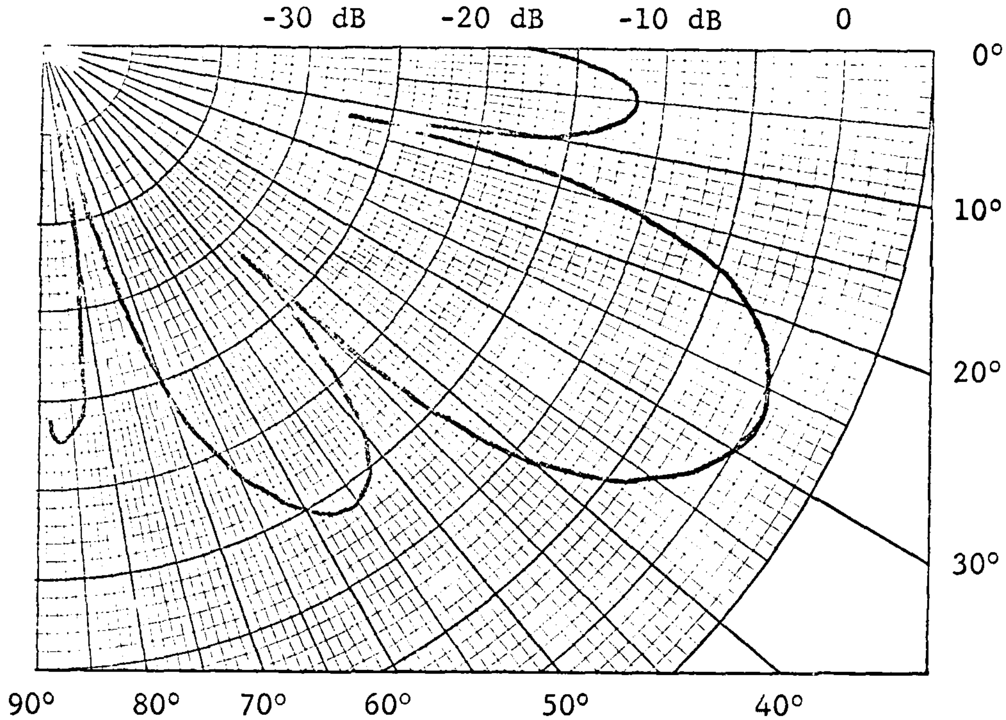
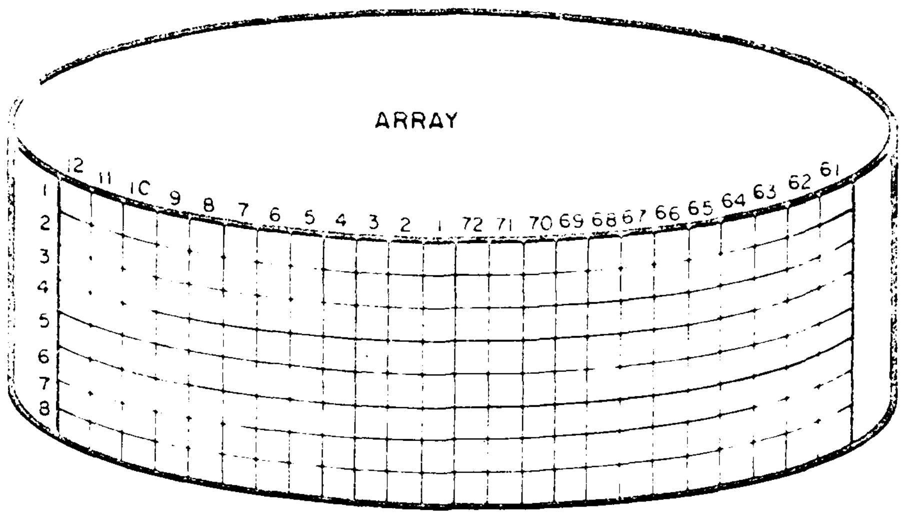


Figure 6 — Vertical Pattern at Bearing 80° for the 8X1 Array - Phase Distortion Due to Fresh Water and a 10°F Temperature Differential Added



HORIZONTAL PHASING

STAVE NO	PHASE	STAVE NO	PHASE
1 & 72	0.0°	7 & 66	272.0°
2 & 71	13.3°	8 & 65	360.5°
3 & 70	39.7°	9 & 64	458.0°
4 & 69	79.3°	10 & 63	566.0°
5 & 68	131.5°	11 & 62	684.0°
6 & 67	196.3°	12 & 61	809.0°

VERTICAL PHASING

LAYER NO.	1	2	3	4	5	6	7	8
PHASE	0°	87°	174°	261°	348°	435°	522°	609°

TABLE 1 - SYSTEM PHASES

Differential Phase Shifts Produced by Fresh Water in the Dome Cavity
80° Bearing; 30° Depression

Stave No. / Layer No. ↓	61	62	63	64	65	66	67	68	69	70	71	72	1	2	3	4	5	6	7	8	9	10	11	12
1	58	54	50	46	42	39	35	33	30	29	27	25	25	25	26	27	28	30	33	36	40	44	50	56
2	57	53	50	45	42	39	36	33	31	29	28	26	25	26	26	27	28	30	33	36	40	45	50	54
3	54	50	48	43	42	38	36	33	31	29	28	27	25	26	27	27	28	30	32	36	40	43	48	52
4	50	47	43	41	38	36	34	31	29	28	26	26	25	25	25	25	27	29	31	34	37	41	45	49
5	45	43	39	37	34	32	30	28	26	25	24	23	22	22	22	23	25	27	29	31	34	37	41	44
6	39	37	34	32	29	27	25	24	22	21	20	19	19	19	19	20	21	23	25	27	29	33	35	39
7	32	29	27	26	24	22	20	19	17	16	16	14	14	14	14	15	16	18	19	21	24	25	28	32
8	24	22	20	18	17	15	14	13	11	10	10	9	9	9	8	9	10	11	13	14	17	18	21	25

Differential Phase Shifts Produced by the Dome Skin and a 10° Temperature Difference *
45° Bearing; 30° Depression

1	45°	44°	42°	42°	42°	42°	42°	41°	40°	39°	38°	38°	33°	33°	32°	32°	31°	30°	30°	30°	30°	30°	30°	30°
2	45°	45°	45°	45°	45°	45°	43°	44°	43°	42°	42°	40°	40°	39°	38°	37°	36°	35°	35°	34°	33°	33°	33°	33°
3	43°	44°	44°	45°	45°	46°	45	45°	45°	45°	45°	44°	43°	42°	41°	40°	39°	37°	37°	36°	35°	35°	35°	35°
4	41°	42°	43°	44°	44°	45°	45°	45°	45°	45°	45°	44°	43°	42°	41°	40°	39°	38°	37°	36°	35°	35°	35°	35°
5	38°	40°	41°	42°	43°	44°	44°	45°	45°	45°	44°	44°	43°	42°	41°	40°	39°	38°	37°	36°	35°	34°	34°	34°
6	36°	38°	39°	40°	41°	42°	43°	43°	44°	44°	43°	43°	42°	41°	40°	39°	38°	37°	36°	35°	34°	33°	33°	33°
7	32°	35°	36°	38°	38°	40°	41°	41°	42°	42°	41°	41°	40°	39°	39°	37°	37°	36°	34°	32°	32°	31°	31°	31°
8	29°	41°	32°	33°	35°	37°	38°	39°	39°	39°	39°	38°	38°	37°	36°	35°	34°	33°	31°	30°	29°	29°	29°	28°

*from Table II, TRACOR Document No. 63-248-C "Some Computed Effects of Dome Skin and Temperature Differential on Operation of the AN/SQS-26 Sonar Equip ment (U)."

TABLE 2- Differential Phase Shifts

IV. SUMMARY and CONCLUSIONS

The results of the vertical pattern computations described in this technical note at a relative bearing of 80° and a tilt of 30° are summarized as follows:

(1) The decrease in beam depression angle is of the order of 1° for fresh water in the dome.

(2) The increase in side lobe level in the vertical plane is less than 0.5 dB for fresh water in the dome.

(3) The major lobe is broadened less than 0.5° for fresh water in the dome.

(4) The effect of a 10° F temperature differential and fresh water in the dome for the "worst case" stave showed only a 2° decrease in beam depression angle.

Using the results of a previous study (See Footnote 2) on the effect of the dome skin on phase shifts, it may be seen that the effect of the dome skin is not more than half the effect of fresh water.

Therefore, it is concluded that the combined effects of fresh water in the dome, a 10° temperature differential, and the dome skin could not cause errors in beam depression or beamwidth of the magnitude observed in the tests on the U.S.S. Wainwright.